Experimental Research of Range of Motion About Wrist Joint

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Abstract. Objective: To investigate the range of motion (ROM) of wrist joint in human body, and the difference about ROMs between man and woman in subgroups and how it relates to age itself;

Methods: One hundred healthy and no movement disorders volunteers from 18–60 years old were recruited to complete the study. They were divided into 2 groups, and half of them are male. The VICON motion capture system was used to measure ROMs of wrist joint. The average value of wrist joint ROMs for each age groups were calculated; The change in the ROM for each age group was compared; The difference in the ROM between male and female was compared, and the difference in the ROMs of wrist joint on the left and right was compared too.

Results: ROMs of wrist palmar flexion and dorsiflexion decreased with the increasing of the age. The difference about ROMs in groups was not significant. Conclusion: The ROMs of wrist palmar flexion and dorsiflexion for normal human decreased with the increasing of the age, but the difference in groups was small.

Keywords: Range of motion · Wrist joint · Motion capture system

1 Introduction

Function sizes of human body should be considered in design of structure and location in various products, so that the operation of products is simple and easy. The function size of human body is produced by the coordinating between the joint rotation angle and the length of limbs. The function size of the human body is determined by the ROM of the human joints on the condition that the length of the limbs is fixed. So far, some Chinese scholars studied the ROMs of the human body, and obtaining some data about ROMs. But these data were measured 10 years ago [1–5]. With the improvement of the Chinese people's living standard, physique and function size may also change; especially for the labor from 18 to 60 these changes may be bigger. Therefore, it is necessary to measure and analyze ROMs of human limb joints again and provide new reliable value about ROMs for the product design with related industries.

ROMs are the measurement of movement around a specific joint of human body [6]. The change in value of published data about ROM is bigger, because it is affected by

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many factors, such as age, gender, physical condition, obesity, nationality, race, occupation and exercise habits. It is also restricted by age, disease and trauma [7]. Activities of joints can be divided into two categories: active and passive. Therefore ROM has two types. One is active ROM, and the other is passive ROM. Active ROM refers to movement of a joint provided entirely by the individual performing the exercise. The human body is in active state when they operate various machines. Therefore active ROM is studied in this paper. Because of the limitation of length, measurement and data analysis about ROM of adult human wrist joint were introduced mainly in this paper.

2 Method

2.1 Subjects

One hundred healthy people agreed to participate in this study. Half of the subjects were male. All subjects were healthy, without limb dysfunction and sports injury. They were divided into two groups: young, middle-aged and elderly. Information of the number of subjects, gender and age was shown in Table 1.

Table 1. Information about subjects

Number of subjects / Ages	18 -40	41 -60
male	40	10
female	40	10

2.2 Measurement Items

In this study ROMs of human wrists was measured. These include wrist palmar flexion, wrist dorsiflexion, wrist radial deviation, wrist ulnar deviation.

ROM of human body joints was measured by using VICON motion capture system of British Oxford Metrics Limited Company [8–10]. Kinestate of moving objects can be captured by the multiple cameras distributed in space of this system and stored in the form of image. Then these image data will be processed. At last coordinates of moving objects in space at different moments will be gotten. To obtain the location of mark point when measuring ROM of wrist joint, preliminary experiments were performed based on the characteristics of human wrist joint activities. To different ROM of joint, witch ball will be stuck to the location of subject's joint when measuring ROM. To each ROM of joint a corresponding motion template will be established in VICON system. In the VICON system operation for each template of motion establishes a

corresponding movement. An example of wrist palmar flexion was shown in Fig. 1 to illustrate the location of witch ball, the location of marker points in VICON system and the template of the motion model.

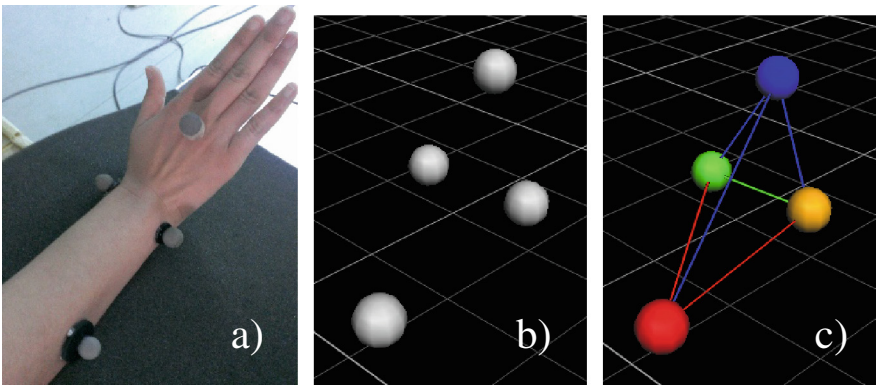

Fig. 1. A sketch about positions of marker points on the human body, the location of witch ball, and movement template when measuring wrist palmar flexion

To each joint ROM, it has definite starting position and its end position based on the characteristics of human activities. To ensure the reliable and unified of experimental data, measurement was repeated three times. For example, when measuring flexion of the wrist, according to the staring position and end position of witch ball (corresponding to the staring position and end position of joint), mathematical model will be established (namely: the angle between two planes. One plane is composed of red, yellow and green ball, and the other is composed of yellow, green and blue ball). Then joint ROM is obtained by solving this mathematical model.

3 Measurement Results

Tables 2 and 3 showed the test results:

(1) For different ROM of wrist joints, the left and right of ROM are different. But the difference between the left and the right is small;
(2) For ROM of radial deviation and ulnar deviation, ROM of the elderly is slightly greater than the young;
(3) Individual difference of ROM is bigger (the range of ROM for dorsiflexion on the left side is from 19.3° to 88.5°, and the difference between the maximum value and the minimum value is 69.2°);
(4) For the men and women of the same age, ROM for wrist joint is different. But the difference is small;

Table 2. ROM of left wrist joint

Joint / Average value	Wrist(left)			
	Palmar flexion	Dorsiflexion	Radial deviation	Ulnar deviation
Male and female	40.8	56.1	23.3	17.6
Female	41.0	54.0	23.3	17.0
Male	40.6	58.3	23.3	17.9
Young	42.1	57.8	23.6	17.0
Young female	43.4	54.0	24.1	16.9
Young male	40.9	61.8	23.0	17.1
Middle-aged and elderly	38.1	53.2	22.7	18.4
Middle-aged and elderly female	36.3	53.8	21.6	17.2
Middle-aged and elderly male	40.0	52.7	24.0	19.8

Table 3. ROM of right wrist joint (degree)

Joint / Average value	Wrist(right)			
	Palmar flexion	Dorsiflexion	Radial deviation	Ulnar deviation
Male and female	40.1	59.1	26.2	16.6
Female	39.7	58.5	25.3	16.2
Male	40.4	59.7	27.1	17.0
Young	41.3	60.2	25.9	15.5
Young female	40.4	58.9	24.8	15.3
Young male	42.3	61.6	27.0	15.7
Middle-aged and elderly	37.8	57.2	26.8	18.7
Middle-aged and elderly female	38.3	58.9	26.3	17.8
Middle-aged and elderly male	37.4	56.7	27.4	19.6

As shown in Fig. 2, the median of ROM of left ulnar deviation is 17.4°, and most data concentrate around it. The deviation in the results is 4.7°; the upper bound and the lower bound of the results are given based on it. About 97 percent of the subjects are in this range. As shown in Fig. 3, the median of ROM of left dorsiflexion deviation is 57.3°, and most data concentrate around it. The deviation in the results is 12.7°; the upper bound and the lower bound of the results are given based on it. About 95 percent of the subjects are in this range. As shown in Fig. 4, the median of ROM of left radial deviation is 22.7°, and

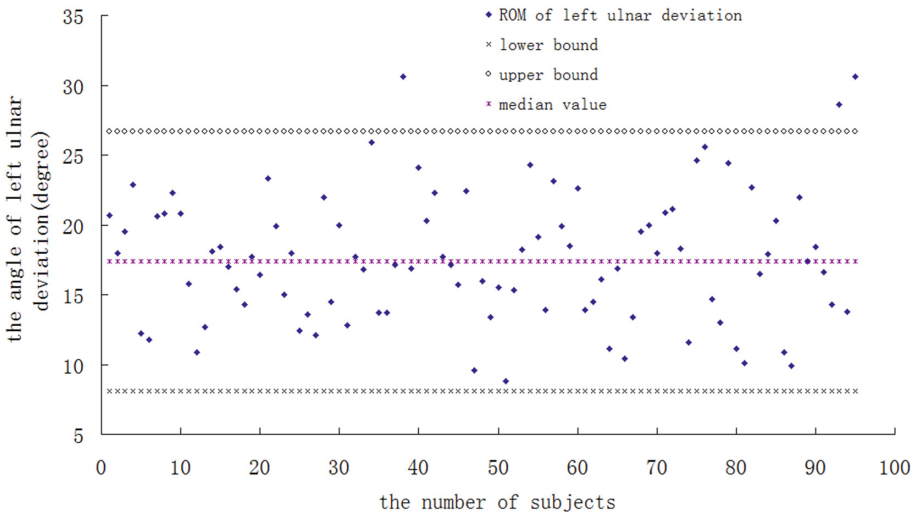

Fig. 2. The angle of left ulnar deviation

most data concentrate around it. The deviation in the results is 6.4°; the upper bound and the lower bound of the results are given based on it. About 97 percent of the subjects are in this range. As shown in Fig. 5, the median of ROM of left palmar flexion is 40.2°, and most data concentrate around it. The deviation in the results is 9.4°; the upper bound and the lower bound of the results are given based on it. About 97 percent of the subjects are in this range. Results that lie outside the upper bound and the lower bound in Figs. 2, 3, 4 and 5 could be abnormal data caused by the individual difference (the age or special professional background).

As shown in Fig. 6, the median of ROM of right ulnar deviation is 16.2°, and most data concentrate around it. The deviation in the results is 5.7°; the upper bound and the lower bound of the results are given based on it. About 98 percent of the subjects are in this range. As shown in Fig. 7, the median of ROM of right dorsiflexion is 60.5°, and most data concentrate around it. The deviation in the results is 12.2°; the upper bound and the lower bound of the results are given based on it. About 96 percent of the subjects are in this range. As shown in Fig. 8, the median of ROM of right radial deviation is 26.1°, and most data concentrate around it. The deviation in the results is 8.3°; the upper bound and the lower bound of the results are given based on it. About 95 percent of the subjects are in this range. As shown in Fig. 9, the median of ROM of right radial deviation is 39.7°, and most data concentrate around it. The deviation in the results is 10.6°; the upper bound and the lower bound of the results are given based on it. About 95 percent of the subjects are in this range. Results that lie outside the upper bound and the lower bound in Figs. 6 and 7 could be abnormal data caused by the individual difference (the age or special professional background).

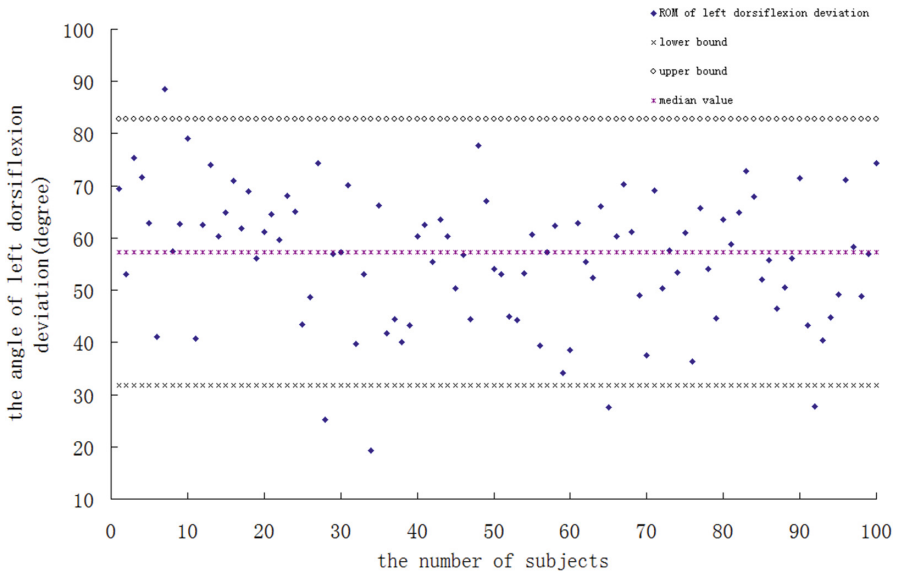

Fig. 3. The angle of left dorsiflexion

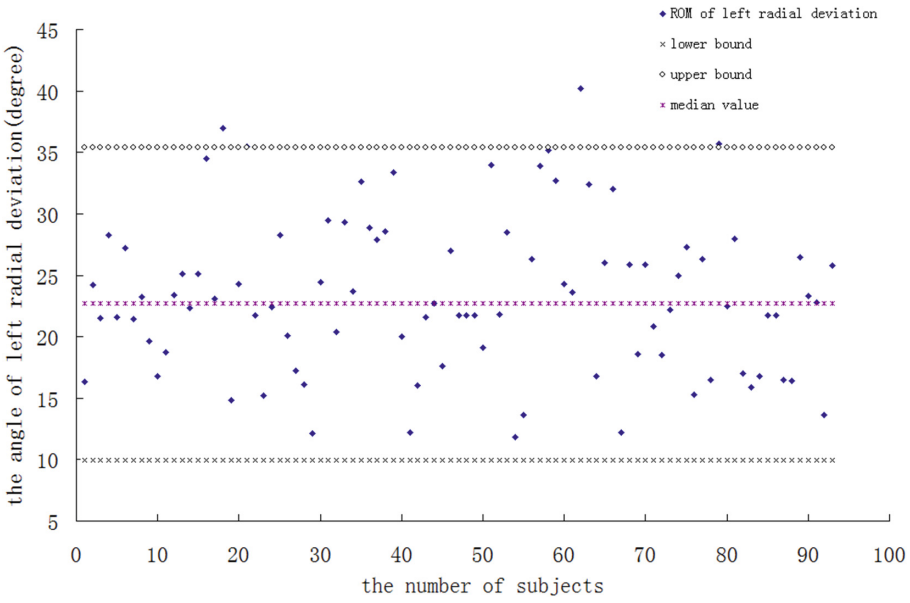

Fig. 4. The angle of left radial deviation

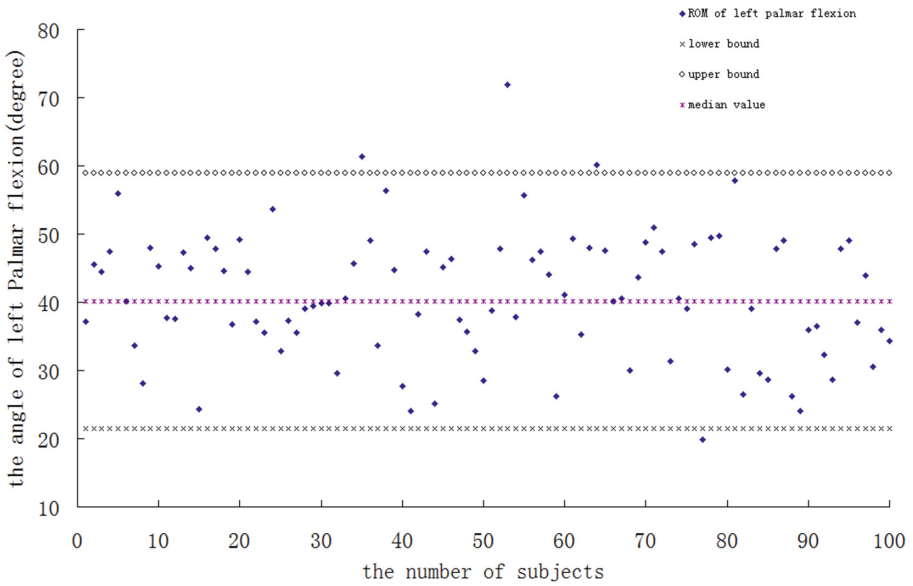

Fig. 5. The angle of left palmar flexion

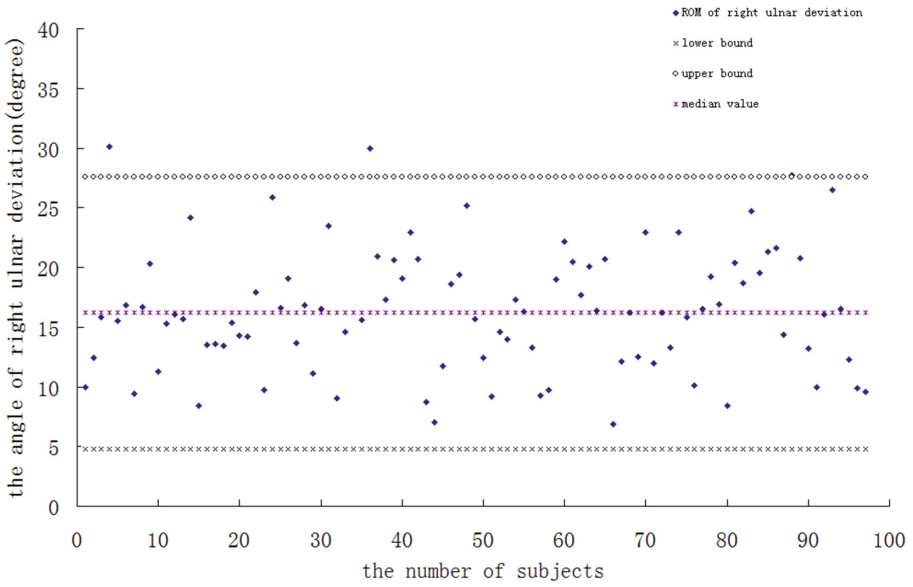

Fig. 6. The angle of right ulnar deviation

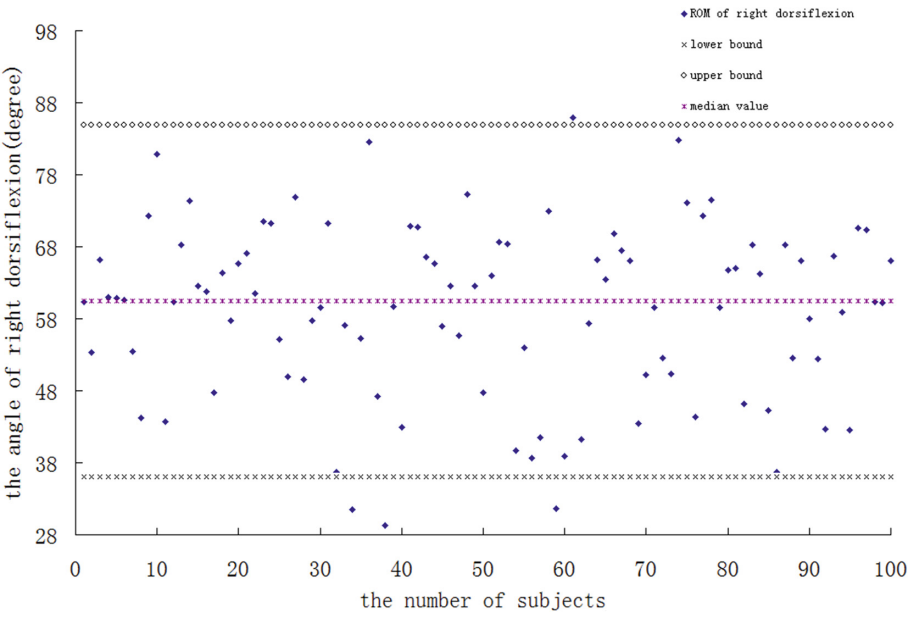

Fig. 7. The angle of right dorsiflexion

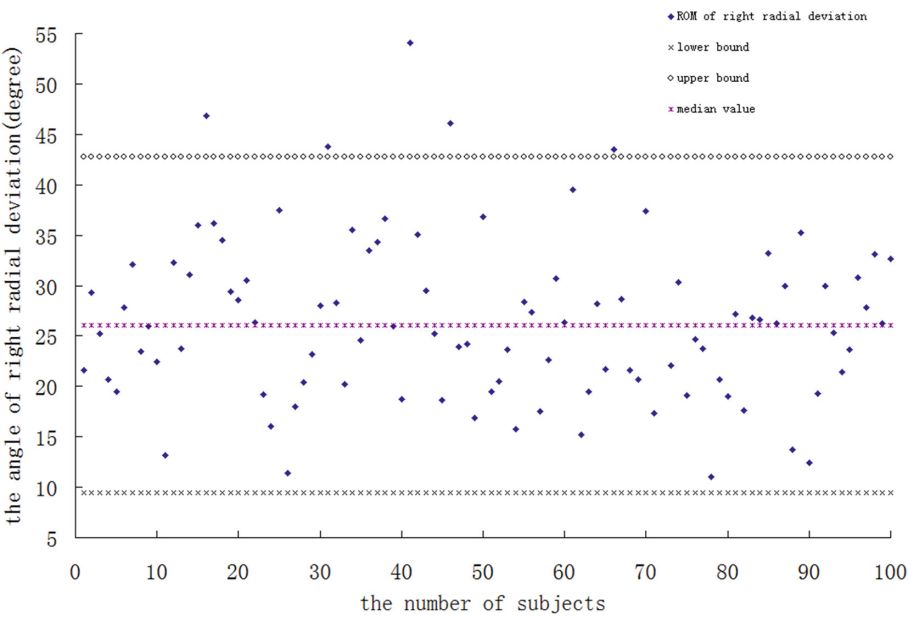

Fig. 8. The angle of right radial deviation

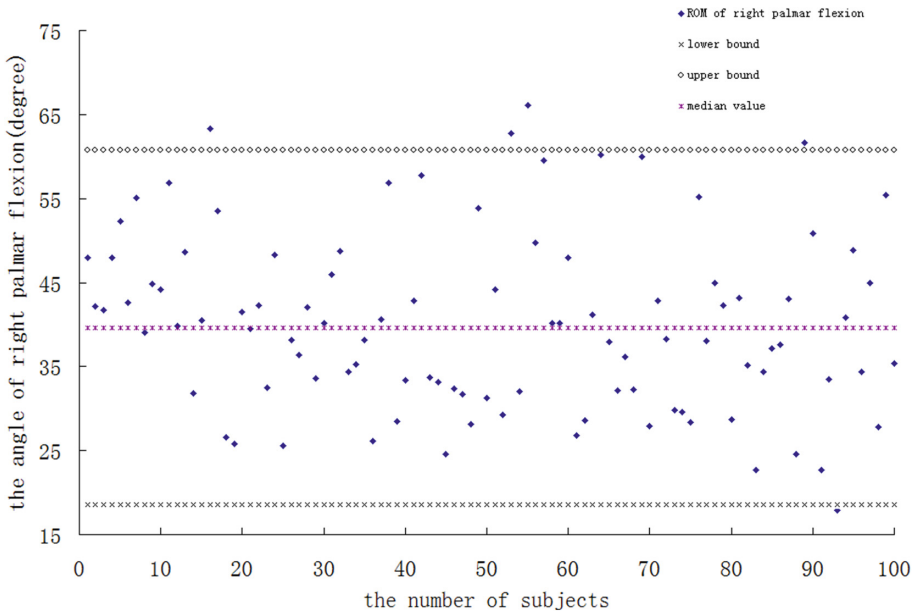

Fig. 9. The angle of right palmar flexion

4 Discussions

In this study the ROM of wrist joints in human body was investigated. The difference about ROM between man and woman in subgroups was analyzed and how it changes with age; One hundred volunteers were recruited. They were divided into 2 groups, and half of them are male. VICON motion capture system was used to measure ROM of wrist joint. The average value of wrist joint ROM for each age groups were obtained; The change in the ROM for each age group was compared; The difference in the ROM between male and female was compared, and the difference in the ROM of wrist joint on the left and right was compared too.

Previous study shows that wrist joint ROM was influenced by the age and sex of subjects [1]. With increasing age, aging occurs in the human body and the skeletons, muscles atrophy occurs and the extent of male is bigger than female. All these decrease wrist joint ROM and the decreased extent of male is bigger than female. In this study the change of ROM for palmar flexion and dorsiflexion with the age is the same as the previous study. But the change of ROM for radial deviation and ulnar deviation with the age had no obvious laws, and the change of magnitude is small. It may be related to the less number of subjects in this study, and it may also be related to the big individual's difference of ROM. But at least, in the general population, the ROM of radial deviation and ulnar deviation is not particularly close to the age (between 18 and 60 years old).

There are deficiencies in this experiment study. Due to the low number of subjects, subjects range in age from 18–60 years, and only 96 data are valid. Therefore, the

results obtained from these data only represent a part of Chinese people, and not the entire Chinese people. Further study needs to be done to get accurate results by increasing the number of samples reasonably.

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